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An Evaluation of the Effects of the Scotch Block Reservoir on the Water Quality of Middle Oakville Creek

AN EVALUATION OF THE EFFECTS OF THE SCOTCH BLOCK RESERVOIR ON THE WATER QUALITY OF MIDDLE OAKVILLE CREEK

report prepared by

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INTRODUCTION

During 1969-71, the Halton Region Conservation Authority constructed the Scotch Block Reservoir on Middle Oakville Creek primarily for purposes of flood control. In June of 1971, as a result of hydrogen sulfide odours immediately downstream from the reservoir, a request was received by the Ministry of Environment (formerly the Ontario Water Resources Commission) from personnel of the Authority, to investigate water quality conditions in the reservoir. However, the resulting survey was designed primarily to evaluate the quality of water in the reservoir itself. On September 11, 1972, a further assessment was undertaken to determine the effects of the reservoir on the water quality of Middle Oakville Creek and the following report outlines the results of this latter study.

The Scotch Block Reservoir is located in Halton County, Esquesing Township, two concessions south of Acton via Highway 25. Surface area is approximately 64 hectares (130 acres) and the maximum depth at the high water level is about 13 meters. The reservoir is supplied with water from several tributaries of the Middle Oakville Creek system; inflowing tributaries are free of contaminants from industrial or municipal wastes.

METHODS

The 1972 survey was carried out during a single visit to the study area. Sampling locations were established at various intervals along the creek as illustrated in Figure 1. Stations A and B, located upstream from the reservoir, were sampled to provide control data. A single sampling location designated as station C was sampled at approximately the deepest point in the reservoir. The downstream locations (D, E, F and G) were situated in such a manner so as to provide an insight into the distance and degree of impact the reservoir has on the receiving waters.

Chemical, Physical

Chemical measurements made in the field by means of a standard Hach Engineering Kit consisted of pH, dissolved oxygen, ammonia nitrogen, carbon dioxide and hydrogen sulphide. All of these parameters were measured at each stream station and at various depths at station C. In addition, two grab samples of surface water were collected at each stream station for laboratory analyses of B.O.D., nitrogen and phosphorus. At station C, B.O.D., nitrogen and phosphorus samples were collected at a depth of 1.0 meter (C"a") and 9.5 meters (C"b"). One sample for chlorophyll analyses was collected at a depth of 1.0 meter at station C. Depth samples in the reservoir were obtained using a Kemmerer water sampler.

At station C on the reservoir, water transparency was determined by means of an eight-inch diameter secchi disc and temperature determinations were obtained from a hydrographic thermometer at each meter of depth in order to establish the thermal profile of the reservoir.

At each stream station, temperature measurements were taken with the hydrographic thermometer.

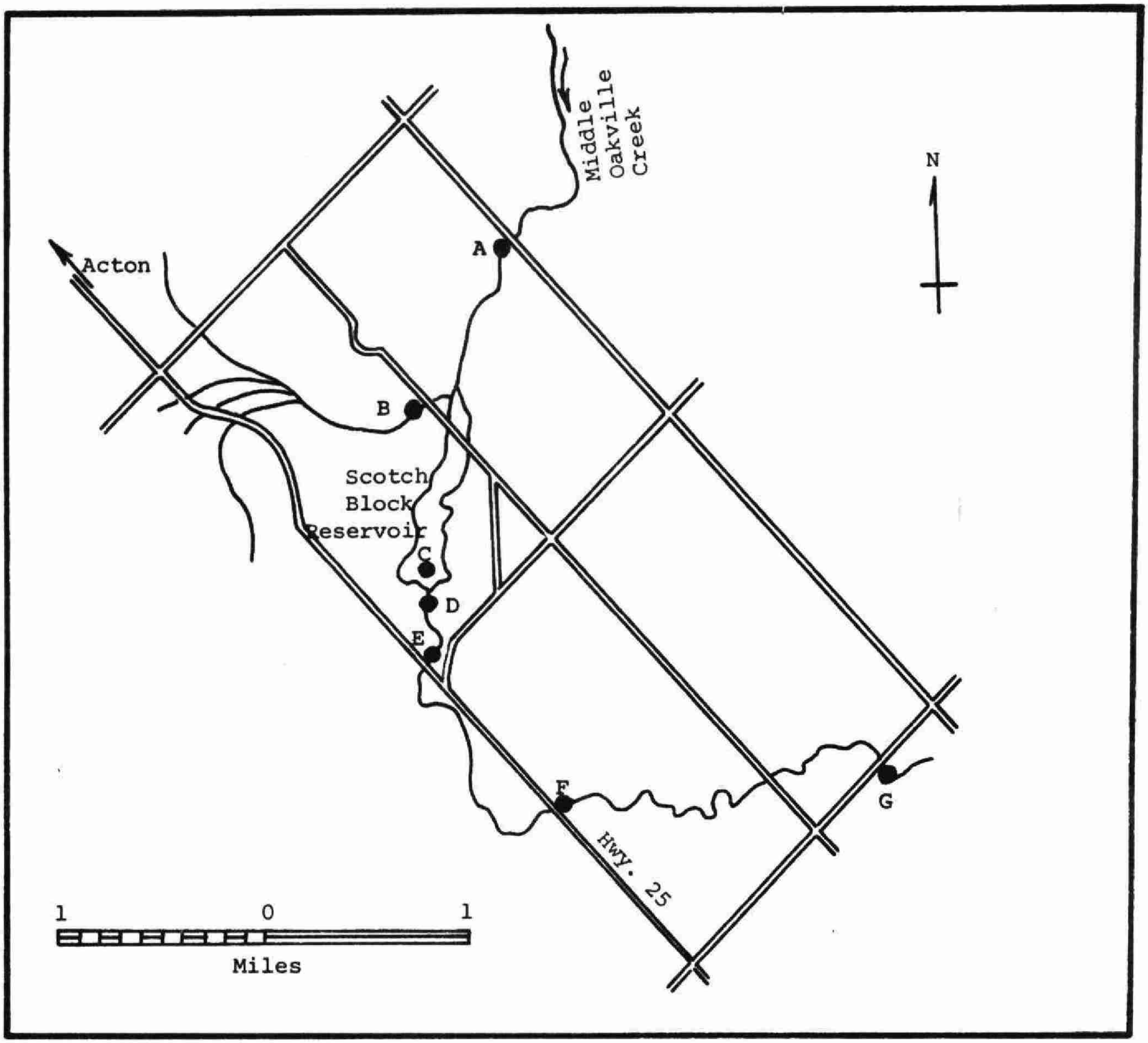


Figure 1: Sampling Locations on Middle Oakville Creek and Scotch Block Reservoir.

Bottom fauna:

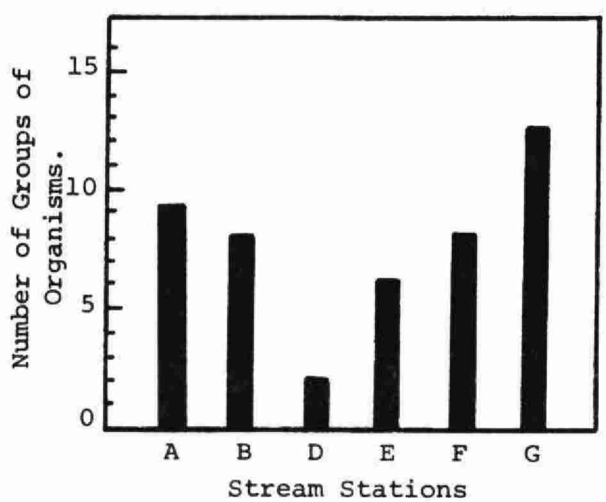
Bottom invertebrates were sampled at each of the stream stations using a hand sieve. Organisms were collected on a 15 minute,time-qualitative basis. The invertebrates were identified in the field and discarded.

RESULTS

The laboratory results of the chemical samples collected during the survey are included in the tables appended to this report. Also included are field chemical measurements and a summary of the bottom faunal communities identified at each of the stream stations.

Biological:

The variety of organisms is illustrated in the figure below and summarized in Table 1 of the Appendix.



Structure of the benthic community at stations D and E, with respect to both the number and variety of organisms present, was characteristically that of a community normally associated with organically-enriched waters. Station D was characterized by an extremely dense population of midge fly larvae and station E supported an abnormally high density of isopods. In contrast, locations A, B, F and G contained balanced communities indicative of unimpaired water quality.

Physical - Chemical:

a) Creek Data - Table 2 illustrates the data obtained in the field using a Hach Engineering Kit and a hydrographic thermometer. Table 3 provides the results of analyses conducted at the Ministry of the Environment Laboratory in Rexdale. The difference in ammonia values between the two tables reflects both 1) the inaccuracy of the field measurements and 2) the instability of this compound. It must be kept in mind that Table 1, except for the temperature data, provides approximate values.

The dissolved oxygen values (Table 2) reveal severe impairment immediately downstream from the reservoir at station D, and moderate impairment at station E. Values at F and G were comparable to the upstream conditions.

Field measurements of carbon dioxide, hydrogen sulfide and ammonia all revealed substantial impairment at station D. Increased levels of carbon dioxide were detected downstream as far as station F and elevated levels of ammonia were found at both D and E.

The laboratory analyses of the six creek samples also revealed substantial upstream-downstream differences in water quality (Table 2). Ammonia levels were elevated at D, E and F, Kjeldahl nitrogen was higher at all four downstream stations, nitrite was high at F and nitrate was high at A, F and G. The high nitrite value at F (0.064 mg/l) probably is a result of rapid oxidation, in this stretch of the stream, of the reduced nitrogenous materials being released from the reservoir. The same explanation can be provided for the higher nitrate concentrations at F and G. The exceptionally high nitrate value of 4.8 mg/l at A is unexplainable and is assumed to be the result of either a non-representative sample or an analytical error. Total and soluble phosphorus values were considerably higher at D and E than at the upstream control stations. Further downstream, at F and G, concentrations approached control values.

As with the other chemical parameters, B.O.D. values below the reservoir were higher than the upstream background levels, a further indication of the poor quality of water being discharged from the Scotch Block Reservoir.

b) Reservoir Data (Station C) - The vertical temperature profile of the reservoir (Table 4) revealed a gradual, minor temperature decrease from surface to the 9 meter depth. However, there was a $3^{o}C$ decrease in the bottom meter of water (9-10m). These data would indicate a moderate degree of vertical mixing and heat transfer throughout most of the reservoir with a small area at the bottom being quite stagnant.

The field data on dissolved oxygen, pH, carbon dioxide and ammonia (Table 4) demonstrates major water-quality problems in the reservoir at the time of sampling. Concentrations of dissolved oxygen were reduced to 2.8 mg/l at the three-meter depth. At and below the seven-meter depth the reservoir water was totally anaerobic.

As would be expected, the lack of dissolved oxygen in the bottom waters was accompanied by depressed pH, and increased levels of carbon dioxide, hydrogen sulfide and ammonia. The latter three compounds are major products of the decomposition of organics which persist under anoxic conditions. All samples collected at and below the seven meter depth had a strong hydrogen sulfide odour.

Table 3 illustrates the concentrations of nitrogen and phosphorus in the bottom waters of the reservoir (C "b"). These values are indicative of very enriched conditions. The high concentrations of ammonia, Kjeldahl nitrogen, soluble and total phosphorus in the bottom would indicate extensive release of these materials into the reservoir waters from the bottom sediments. While the surface waters of the reservoir (C"a" in Table 3) had considerably lower levels of nitrogen and phosphorus than did the bottom waters, the surface waters were considerably more enriched than the two significant inflowing tributaries, particularly in terms of nitrogen. This information further substantiates that the entire body of the reservoir is of considerably poorer water quality than the feeding creeks. The study also revealed a high degree of phytoplankton production in the reservoir and attendant poor water clarity. The Secchi disc reading at station C was limited to 1.0 meter and the concentration of chlorophyll 'a', which reflects

the standing crop of planktonic algae, was 21 mg/m^3. As a point of clarification, chlorophyll 'a' values in the 2.5 mg/m^3 range are considered low and indicate low to moderate algal concentrations. Values between 5 and 10 mg/m^3 reflect moderately high phytoplankton production but are still considered acceptable for most water-oriented recreational pursuits. Levels of 15 or higher reflect nuisance levels of algae and severe degradation of water quality for most uses.

c) Odour and Visual Observations - As mentioned previously, the hydrogen sulfide odours below the impoundment originally led to the investigation. During both the 1971 and 1972 visits, strong odours of this gas were noted in samples collected from the bottom waters of the reservoir as well as in the creek water just below the impoundment. Fortunately, hydrogen sulfide is readily oxidizable and none was detected either in the air or water a short distance downstream at station E.

The creek bottom, just below the dam, which consists of man-made, wire-mesh boxes filled with crushed limestone, was found to be heavily coated with a milky-green "slime". This slime was identified after the 1971 visit as primarily the blue-green filamentous alga Lyngbyia. It is surprising that this alga can exist where the concentration of hydrogen sulfide was measured at >5 mg/l. Further downstream (E, F and G), both aquatic vascular plants and filamentous algae flourished.

Another observation of interest is that the creek waters at D and E had an abnormal blackish appearance. Unfortunately colour was not measured.

CONCLUSIONS

The Scotch Block Reservoir during the late summer period is characterized by anaerobic conditions in the bottom waters and this condition has given rise to a number of other water quality problems - hydrogen sulfide, high ammonia, leaching of nutrients and organics from the bottom muds. It is probable that the high rate of oxygen consumption in the reservoir is primarily a result of rapid mineralization of the newly flooded land. However, other factors including the shape and depth characteristics of the reservoir, and the naturally-enriched character of Middle Oakville Creek, no doubt add to the problem. While new impoundments have been known to revert from bottom anaerobism to bottom aerobism after a few years of bottom stabilization, the severity of the problem in the Scotch Block Reservoir would indicate that bottom anaerobism may be a permanent problem unless corrective measures are undertaken.

Due to the bottom-water evacuation system, the anoxic reservoir waters are released back into the creek system and cause severe downstream water-quality problems. The problems are similar in some respects and more critical in others to the water quality impairment one might expect from a small municipality at the same site discharging inadequately treated wastes to the stream. Water quality is considerably impaired in the stretch of creek between the reservoir and Highway #25 - a distance of approximately one-half mile. There is evidence of some impairment at station F - about one and three quarter miles downstream from the reservoir; at station G, located about four miles downstream, recovery appears to be complete.

RECOMMENDATIONS

It is recommended that the Halton Region Conservation Authority investigate methods of improving water quality conditions of the reservoir in order to prevent impairment of water quality in Middle Oakville Creek. An artificial aeration system is presently in use on the Valens Reservoir (Hamilton Region Conservation Authority) and the Halton Authority may wish to investigate the feasibility of using a similar system on the Scotch Block Reservoir.

It is recommended that the Ministry of Environment (Water Quality Branch) work closely with the authority in deciding on a suitable management technique. Studies should also be undertaken in order to evaluate the effects of the corrective technique that is selected.

APPENDIX

Table 1: Groups of organisms collected at each stream station, September 11, 1972.

STATION	GROUPS OF ORGANISMS
A	Snails Fingernail clams Diptera larvae Midge larvae Beetles Crayfish Amphipods Water boatmen Water striders
B	Snails Fingernail clams Diptera larvae Midge larvae Beetles Amphipods Water boatmen Water striders
D	Snails Midge larvae
E	Snails Fingernail clams Midge larvae Water boatmen Isopods Sludgeworms
F	Snails Fingernail clams Midge larvae Beetles Crayfish Dragonflies Damsel flies Water boatmen

Table 1 cont'd.:

STATION	GROUPS OF ORGANISMS
G	Snails Fingernail clams Midge larvae Beetles Crayfish Diptera larvae Water boatmen Water strider Mayflies Damselflies Amphipods Sludgeworms

Table 2: Chemical measurements made in the field at the 6 stream stations using a standard Hach Engineering Kit and Hydrographic Thermometer, September 11, 1972.

STATION	D.O. (mg/l)	pH	Temperature (°C)	CO_2 mg/l	H_2S (mg/l)	NH_3 (mg/l)
A	11.0	8.3	15.0	12.0	0	0.3
B	10.0	8.7	16.0	12.0	0	0.3
D	1.5	7.3	17.0	40.0	>5.0mg/l	2.2
E	5.0	8.4	19.0	20.0	0	1.6
F	11.0	8.5	17.5	24.0	0	0.3
G	14.0	8.9	18.0	6.0	0	0.0

Table 3: Laboratory results of chemical analyses on samples collected at all stream stations, September 11, 1972.

STREAM STATION	NITROGEN AS N Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	PHOSPHORUS AS P Tot.	Sol.	5-day BOD	Chlorophyll 'a'	'b'
A	.01	.40	.013	4.8	.050	.016	0.4	-	-
B	.01	.36	.005	.02	.028	.008	0.4	-	-
C'a'	.22	1.0	.008	.02	.064	.002	2.5	21.0	0.7
C'b'	1.7	2.4	.008	.01	.16	.064	1.8	-	-
D	1.2	1.9	.007	.01	.12	.050	2.0	-	-
E	1.1	1.8	.020	.04	.13	.042	1.8	-	-
F	.06	.78	.064	.71	.065	.022	1.0	-	-
G	<.01	.56	.020	.51	.043	.016	0.8	-	-

Note: All data in mg/l except for BOD and chlorophyll. Chlorophyll in mg/m^3.

Table 4: Chemical and physical measurements determined in the field by means of a standard Hach Engineering Kit, Hydrographic Thermometer and Secchi disc, September 11, 1972.

DEPTH (m)	D.O. (mg/l)	pH	Temperature (^{0}C)	CO_2 (mg/l)	H_2S (mg/l)	NH_3 (mg/l)
Surface	7.0	8.6	20.0	8.0	0.0	0.6
1.0	6.5	8.5	20.0	16.0	0.0	0.6
2.0	-	-	19.7	-	-	-
3.0	2.8	8.2	19.5	20.0	0.0	0.6
4.0	-	-	19.4	-	-	-
5.0	2.6	8.0	19.3	-	0.0	0.6
6.0	-	-	19.1	-	-	-
7.0	0.0	7.7	18.4	24.0	1.5	1.0 - 1.5
8.0	-	-	17.7	-	-	-
9.0	0.0	7.5	17.0	40.0	>5.0	2.0 - 3.0
10.0	-	-	14.0	-	-	-

Secchi Disc - 1.0 m.